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IMPROVED OXIDATION RESISTANCE OF MOLYBDENUM BY ALLOYING WITH RARE EARTH AND OTHER SELECTED METALS

1 February 1963

Prepared under Navy, Bureau of Weapons
Contract No. NOw 62-0305-d

Interim Report No. 7

1 November 1962 to 31 December 1962

Colorado School of Mines
Research Foundation, Inc.

Golden, Colorado

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Report On

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Approved:

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INTRODUCTION

In Interim Report No. 6 we gave the results obtained by selective oxidation of moly-hafnium alloys at 1.0, 5.6, 15.0, and 25.0 atom percent hafnium at 1200°C and 1300°C, and at two different partial pressures of oxygen. As outlined in that report this work has been extended to 1100°C in order to get a more reliable picture of the effect of temperature upon the diffusion rates of hafnium and of oxygen.

SUMMARY

The diffusion rates of hafnium and of oxygen in the alloys during the process of internal oxidation obey the Arrhenius law, $D = Ae^{-E/RT}$, as evidenced by straight line plots of log D vs 1/T, as was expected. This is substantiated by data at three temperatures, 1100°C, 1200°C, and 1300°C. The equations used in presenting the results in Interim Report No. 6 were straight line approximations of the form

$$\frac{X^2}{t} = \frac{2D_OC_O}{\frac{O}{m}C_m} - 1.68\ D_{Hf}$$

Actually, this was an oversimplification. The relationship between $\frac{X^2}{t}$, D_OC_O, and D_{Hf} is actually more complex than this. More accurate equations are being prepared, and the resulting more accurate values of D_OC_O, and D_{Hf} at the temperatures, alloy compositions and partial pressures of oxygen used will be

reported in the next Interim Report. Values of $\frac{X^2}{t}$ are reported in Table 1.

EXPERIMENTAL RESULTS

1. Experimental results at 1200°C and 1300°C were presented in Table 1 and Table 2, p. 5, of Interim Report No. 6. Experimental results at 1100°C are herewith presented in Table 3.

TABLE 3

EXPERIMENTAL RESULTS AT 1100°C

Experiment No.	Atom % Hf	X(cm)	t(sec)	$\frac{X^2}{t}$
5-9a	1.0	0	426,000	0
5-4a	5.6	0.002	426,000	9.39×10^{-12}
5-8a	15.0	0.0015	426,000	5.285×10^{-12}
5-9b	1.0	0	426,000	0
5-4b	5.6	0.00325	426,000	24.75×10^{-12}
5-8b	15.0	0.0025	426,000	14.67×10^{-12}

In Table 3, $_{Hf}$ and D_OC_O have not been given as was done in Tables 1 and 2 of Interim Report No. 6. This is because the equations for solving these values are being revamped as explained in the Summary.

PROPOSED WORK FOR THE PERIOD JANUARY 1, 1963, TO FEBRUARY 28, 1963

1. The task of revamping the mathematics for solving for C_OD_O and D_{Hf} will be completed and all values of these parameters for all conditions studied will be reported. When this data has been properly analyzed the conditions for growing external scales

on Mo-Hf alloys will have been defined and work will proceed in that direction. A brief idea of the computations involved can be gained by referring to p. 6-11 of Interim Report No. 6. The equations that are being developed are more complex, but the work is rapidly being put into shape.